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VIRGINIA
AGRICULTURAL EXPERIMENT STATION.

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AN EXPERIMENT IN GENERATING VINEGAR.

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AN EXPERIMENT IN GENERATING VINEGAR.

As recorded in Bulletin 57, an experiment in the manufacture of by-products from unmerchantable apples was begun during the fall of 1895. The preliminary stages of this work were reported in the above-mentioned Bulletin. Since that publication, some further work has been done in an experimental manner to determine the feasibility of manufacturing vinegar by modern methods on the average farm.

In pursuance of this experiment, a small outfit, comprising one four by eight feet generator, beech shavings and accessories were purchased and set up in an old storage building for the experiment. The generator is a large tank, strongly made from two-inch whitewood planks and heavily hooped with five one-half inch iron rods drawn up by lug bolts. One foot from the top of this tank, is placed a perforated wooden disk over which the stock solution is evenly distributed by a dumper. The perforations in the disk are one-eighth inch gimlet holes. Through these the liquid percolates into the mass of shavings in the body of the generator. It is necessary that this disk be set level and tightly packed about the edge to insure even percolation of the fluids. Also, the small holes are apt to become clogged and must receive attention. The dumper is a double wooden trough so mounted on supports at the end that when one side is full, it rocks over and presents the other trough under the spigot. This process repeats itself at greater or less intervals according to the flow of liquid. The top of the generator tank is covered with a moveable board cover pierced by an opening through which the stock flows to the dumper. This cover is necessary to prevent excessive evaporation and for cleanliness. Above the generator, situated near by, or elsewhere as may suit the convenience, is a tank containing the stock to be generated. In our outfit, this tank is a fifty-gallon barrel supported immediately above the edge of the generator tank.

It is necessary in putting up an apparatus of this sort to avoid the use of iron or other metals of any kind which will be corroded by acetic acid, consequently we used wooden spigots and glass rods or rubber tubing where it was necessary to convey the stock liquids or the finished vinegar.

Prior to putting in the perforated disk or arranging the supply tank or dumper, the body of the generator was filled with beech shavings. These are manufactured especially for this purpose and are heavy shavings one inch wide, tightly coiled, so that they present the appearance of small cylinders. The purpose of these shavings is to spread the liquid to be converted out over a large area of surface as it slowly trickles over them. This permits the rapid oxygenation or conversion of the alcohol in the stock into acetic acid.

Before filling the generator with shavings, a bunghole was bored with downward slant six inches above the bottom of the tank and into this was tightly fitted a siphon made from one-fourth inch glass tubing. On the inside, this tube extended to the bottom of the tank and was protected by a cage of wooden strips pinned to the tank. The outer end of the siphon, was connected with rubber tubing which extended into the storage celler below the storeroom.

Two inches above the siphon, eight one-half inch holes were bored around the tank on a level and sixteen inches above this line, a second line of six holes were bored. These are for the free admission of air to the body of the tank. The fermentative process cannot proceed properly without a sufficient supply of air. These vent holes are also bored with a downward slant so that any fluids trickling down the sides of the tank cannot escape. A thermometer was inserted several inches into the shavings at one of the lower and one of the upper vent holes.

Generating vinegar by this process is essentially identical with the fermentation which would go on slowly in the barrel by the old methods commonly adopted on the farm. It is simply a hastening or forcing process. In this manner it is possible to complete the fermentation and put the product on the market much sooner and, what is still more important, it enables the manufacturer to prepare a standard vinegar with certainty, which is quite impossible under the old haphazard methods.

The fact that vinegars made on the farms are usually very unreliable as to acidity and keeping quality is well known, but I think no particular data has been collected on this subject for this State. Dr. William Frear has just published data relating to such an investigation in Pennsylvania from which I extract the following statement. Sixty-four samples collected direct from the makers were examined by Dr. Frear and the per cent. of acetic acid found to vary from 0.86 per cent. to 8.79 per cent. Fourteen out of the sixty-four samples fell below four per cent. of acetic acid, the legal requirement in Pennsylvania. It is very probable that an examinaiton of home-made vinegars in Virginia would show an equally unsatisfactory state of affairs, and this fact of unreliability may have to do with the other very patent and unpleasant fact that the cheap vinegars made as by-products at distilleries and other manufacturing plants have so readily captured our markets and practically driven those who do make a fine cider vinegar out of the business.

RUNNING THE GENERATOR.

On July 18th the generator was first charged. Forty gallons of strong vinegar (acidity not determined) was put into the supply tank and with it one quart of ninety-five per cent. alcohol. This was run into the generator rather rapidly for the purpose of acidulating the shavings and starting the cultures of the vinegar ferment (*Mycoderma aceti*). The forty gallons were run through in twenty-four hours. The product was highly colored and deficient in acidity, in fact, from a good vinegar it had been much reduced and injured in character, as is to be expected with the first few charges used in starting a generator. The temperature did not rise in the generator during this period, in fact, it fell from 72° to 70° due to changes in the outside atmosphere.

The second charge was put in the storage tank July 19th at four o'clock p. m., and consisted of twenty gallons of four per cent. vinegar in which was dissolved fifteen pounds of condensed grape juice, *i. e.*, unsugared grape jelly, and twenty gallons of the product of the first charge (acidity of this latter not determined). The spigot was now set to feed very slowly. The temperature in the generator had fallen to 68° F. At seven o'clock the next morning, July 20th, the temperature began to rise slowly and the odor indicated that fermentation was beginning. At three o'clock of this day, the temperature had risen to 84° at lower vent holes and 90° at upper ones. By seven o'clock p. m., it registered 88° and 96° respectively.

The fluid was now passing through the apparatus at the rate of a little less than a gallon per hour and everything apparently working well. At seven o'clock a. m., on the 21st, the mercury registered 96° at the lower vents and 105° at the upper. This temperature being high, the upper vents were all plugged and one-half of the lower ones and we prepared to charge with the cider stock.

It should be stated by way of explanation that it the temperature in the generator should run too high, the alcohol will be volatilized to some extent and loss will result. Hence it is necessary to constantly observe the temperature at one or more points in the apparatus and control the heat developed by admitting more air should it fall below the desired temperature, or by stopping off air if it rise above. It is further important to admit only air enough to cause acetification to go on properly, because all unnecessary draught causes loss by evaporation.

After saturation of the generator was complete, we found that the temperature reading at the lower vent holes was not a reliable indication of the condition of the apparatus. The reading at this point eventually fell and remained fluctuating about 70° to 80° but the temperature at the upper line of vents proved to indicate with great certainty the working condition of the apparatus. So long as the upper thermometer read 90° or above a good product was produced; below that there was some uncertainty depending most likely in some measure upon the stock used. Our observations indicate that the probabilities are that 95° F. is an optimum temperature. At this point good work is done and the apparatus will probably yield its maximum quantity of product with a minimum of loss. The product which ran off from the generator during the three days' preliminary work was so colored and injured in taste that it could not be used.

On the 21st of July, we began charging the generator with vinegar stock which had been held over a year in barrels and failed to become acid enough for market. This stock showed, on test, two per cent. to three and five tenths per cent. of vinegar acid, much of it being of the lower per cent. With this vinegar stock was mixed about an equal quantity of cider which had been preserved for drinking purposes, but had become too acid for use. Unfortunately, no test was made of its acidity. The first product from this stock was still highly colored but was a fairly good vinegar, and we began to store it for commercial use.

From this date, records of the temperature within the generator at two points were taken four times daily and the product running from it was usually tested each morning and evening to determine the acidity. Sometimes this latter point was omitted but not often. These records cover a period of three months. In order to give a more definite idea of the ranges of temperature and the character of the product produced, an abstract from the records covering a period of fifteen days is published. The temperature readings here given were taken two feet above the bottom of the tank, and are, we consider, much more reliable than readings lower down. The readings were made at 7:00 and 10:00 a. m., and at 2:00 and 6:00 p. m. The range is considerable, being from 88° to 106°. This latter is an unduly high temperature and resulted from inattention to cutting off the air supply. While we have not carried out our work on a plan that warrants us in theorizing to any extent, the table bears out the statement made above that high temperature appears to cause loss of alcohol and to weaken the product. The highest percentages of acidity occur with the lower temperatures. However, our further experience showed that a fall below 90° for any length of time was not permissible.

TABLE SHOWING PRINCIPAL DATA FOR FIRST FIFTEEN DAYS RUN.

DATE		TEMPERATURE—Fah.				ACIDITY—%		
Month	Day	A. M.		P. M.		A. M.	P. M.	
		7:00	10:00	2:00	6:00			
July	21	92	93	96	101	....	4.58	During this period, the finished product averaged twenty gallons daily (twenty-four hours). The actual labor of tendance was about one and one-half hours per day. The product was a very fine vinegar.
“	22	102	100	100	102	4.38	4.87	
“	23	102	102	104	104	4.57	4.57	
“	24	102	102	101	100	4.77	....	
“	25	97	97	98	99	....	....	
“	26	97	96	96	96	4 57	4.76	
“	27	97	97	97	97	4.63	4.72	
“	28	94	94	95	95	4.77	5.06	
“	29	90	89	89	90	4.22	....	
“	30	88	87	88	90	5.85	5.87	
“	31	92	93	95	98	5.78	5.62	
August ...	1	100	101	101	100	....	....	
“	2	105	104	104	106	4.54	4.05	
“	3	98	98	98	98	....	....	
“	4	98	97	98	100	4.23	4.35	

It was found to be a very simple matter to run the generator, only requiring intelligent observation of the temperature and attention to controlling the ventilation as indicated by these readings. Also it is of great importance to know something of the nature of the stock being used, but we can safely say that any cider stock in which the alcoholic fermentation is completed can be run through the generator with certainty of a good product in vinegar, if the proper conditions are observed. Controlling the flow into the generator from the supply tank is very important. The dumper used here holds three quarts and it was set to fill about each forty minutes. .

This fall we attempted to use fresh cider mixed half and half with vinegar stock, but it failed to make good vinegar without double working, that is, putting it through twice. Our experience goes to show that for ordinary work it is better to let the cider ferment in casks or tanks for some time before running it through the generator.

This experiment was continued for three months without any hitch, and then discontinued because of the outside temperature falling so low that proper fermentation was checked. This could easily be overcome by fitting up a warm room for the generator, if it was desired to carry on the work during the winter season.

It appears reasonable to conclude that operating a generator presents no unusual difficulties, and that this method of manufacturing vinegar might be successfully introduced with reasonable profit if cheap vinegars made as by-products from various factories, colored and flavored to imitate cider vinegar, were not dumped upon our markets by the carload at ridiculously low prices. The cost of setting up a generator need not exceed thirty or forty dollars. It will last for years. After a run of a few months, the shavings can be removed, carefully washed in hot water, dried and stored for further use. A second cleansing of the shavings would probably not be practical.

In conducting this work I have been greatly assisted by Messrs. W. R. Karr and H. L. Price, students of this institution.

WM. B. ALWOOD,
Horticulturist, Etc.